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I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2002951332 for a patent by VAPORATE PTY LTD as filed on 11 September 2002.

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Twelfth day of September 2003

J R Yabsley

JONNE YABSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

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AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant(s):

VAPORATE PTY LTD

Invention Title:

FUEL DELIVERY SYSTEM

The invention is described in the following statement:

FUEL DELIVERY SYSTEM

Field of the Invention

This invention relates to a fuel delivery system and, in particular, to an improvement to the system disclosed in our International Application No. PCT/AU02/00403.

The contents of the above International application are incorporated into this specification by this reference.

Background Art

Our above-mentioned International application discloses a fuel injection system which heats the end region of a fuel injector so as to elevate the temperature of the fuel in the end region. This results in the fuel converting immediately to vapour when the fuel is ejected from the end region of the injector into an air inlet port of an engine. Thus, as soon as the fuel leaves the injector, the fuel immediately converts to vapour state because of the heating of the fuel in the end region and the change in pressure experienced by the fuel when the fuel leaves the injector. Therefore, the fuel is delivered to the cylinder in vapour form which greatly decreases fuel consumption.

In our aforementioned International application, a number of different ways of heating the end region of the injector are disclosed. One form utilises direct conduction of heat from the engine to the end of the fuel injector.

In the normal configuration of modern engines, inlet ports of the head of the engine are insulated to some degree from the inlet manifold to prevent heat transfer from the head to the manifold to keep the inlet manifold as cool as possible. This, combined with the use of seals on the end region of the injector, prevents any heating of the fuel

in the injector end region.

Summary of the Invention

The object of a first aspect of the present invention is to improve the direct conduction heating of the injector of the type disclosed in the aforementioned International application.

The present invention may be said to reside in a fuel delivery system for a vehicle engine, having at least one cylinder, a piston moveable in the cylinder, and an inlet port for supplying air and fuel to the cylinder, including:

an inlet manifold for supplying air to the inlet port;

a heat conducting gasket between the engine and the inlet manifold;

an injector port in the inlet manifold;

a fuel injector having an end region and a body, the body including componentry for operating the injector, the injector being located in the injector port; and

wherein heat is conducted from the engine via the heat conducting gasket to the inlet manifold, and then to the end region to heat the end region, but not the body of the injector, to elevate the temperature of fuel in the end region, so that when the fuel is ejected from the end region of the injector, the fuel substantially immediately converts to vapour because of the heating of the end region and therefore the fuel in the end region, and the change in pressure experienced by the fuel as the fuel leaves the end region of the injector.

The use of a heat conducting gasket and heat conduction from the gasket to the manifold and then to the heat conducting end region ensures good heat transfer to the end region to elevate the fuel to the required temperature to ensure that the fuel immediately converts to vapour

when the fuel is ejected from the injector.

In one embodiment of the invention, a heat conducting collar is provided around the end region of the injector and in heat conducting contact with the end region, and the collar being in the heat conducting contact with a wall defining the injector port.

In another embodiment, the injector port is sized such that the end region of the injector is in direct heat conducting contact with a wall defining the injector port.

Preferably the gasket includes opposed sides, and at least one opening for providing communication from the inlet manifold to the inlet port, a first raised section surrounding the opening on one side of the gasket, and a second raised section surrounding the opening on the other side of the gasket, so that when the gasket is located between the engine and the inlet manifold, and the inlet manifold secured to the engine, the raised sections deform to form a seal about the opening.

Preferably the gasket is formed in a stamping or pressing operation, and the raised section is formed by a V-shaped projection in transverse cross-section on one side of the gasket, and an offset V-shaped projection in transverse cross-section on the other side of the gasket.

In one embodiment of the invention, a housing is provided for locating over the injector and the injector port to facilitate the retention of heat to heat the end region of the injector.

In one embodiment of the invention, electrical heating means is provided for supplying heat to the end region during initial start-up of the engine before the engine acquires sufficient heat for conduction to the end region

to heat the end region, and therefore the fuel in the end region by heat conducted from the engine.

In one embodiment the electrical heating means comprises an electrical heating pad in electrical contact with the end region, an insulating member between the pad and the engine, and an electrical inductor in electrical communication with the pad so that current is supplied to the pad and then flows through the end region to heat the end region.

In another embodiment the electrical heating means comprises a coil wound around the end region, electric leads for supplying current to the coil so that the passage of current through the coil generates heat to the heat the end region.

This embodiment of the invention may include temperature sensing means for monitoring the temperature of the engine in the vicinity of the fuel injector for switching off the electrical heating means when the engine temperature reaches a predetermined temperature whereby sufficient heat is conducted from the engine to the end region to heat the fuel in the end region.

A second aspect of the invention is concerned with supplying sufficient heat to the end region of the injector during initial engine start-up so that as soon as possible after engine start-up, fuel in the end region of the injector is elevated to the required temperature to substantially immediately convert to vapour as soon as the fuel is ejected from the injector.

This aspect of the invention may be said to reside in a fuel delivery system for a vehicle engine, having at least one cylinder, a piston moveable in the cylinder, and an air port for supplying air and fuel to the cylinder,

including:

an inlet manifold for supplying air to the inlet port;

an injector port;

a fuel injector located in the injector port, the fuel injector having an end region and a body, the body including componentry for operating the injector; and

electrical heating means for heating the end region, but not the body of the fuel injector, to elevate the temperature of the fuel in the end region, so that when the fuel is ejected from the end region of the injector, the fuel substantially immediately converts to vapour because of the heating of the end region, and therefore the fuel in the end region, and the change in pressure experienced by the fuel as the fuel leaves the end region of the injector.

The use of the electrical heating means enables heat to be supplied immediately the engine is switched on and does not require the engine to heat up before sufficient heat is supplied. The time taken for an engine to heat to the required temperature so that the conduction of heat to the injector to heat the injector in the first aspect of the invention may be up to 200 seconds. Whilst this time period is not significant if the engine runs continuously for long periods of time it nevertheless does play some part in the overall fuel consumption of the engine. Obviously, if the engine is switched on and off regularly and cools between restarts, then the start-up period of 200 seconds before the engine reaches the required operating temperature is more significant. The electrical heating means of this aspect of the invention enables heat to be conducted to the end region of the injector much more quickly, which further improves fuel consumption, particularly in the initial period after engine start-up, and until the engine reaches the required operating temperature. This aspect of the invention may therefore

be used only in the first 200 seconds or thereabouts after initial start-up, after which time, heat conducted from the engine can supply the heat to the end region, or, alternatively, could be used as the sole or primary source of heat to the end region to heat the end region to the required temperature to cause the vaporisation of the fuel immediately the fuel leaves the injector.

In one embodiment of the invention electrical heating means is arranged on the outer surface of the end region.

In one embodiment the electrical heating means comprises an electrical heating pad in electrical contact with the end region, an insulating member between the pad and the engine, and an insulated electrical conductor in electrical communication with the pad so that current is supplied to the pad and then flows through the end region to heat the end region.

In another embodiment the electrical heating means comprises an insulated heating coil wound around the end region, and electrical conductors for supplying current to the coil so that the passage of current through the coil generates heat to heat the end region.

In one embodiment temperature sensing means is provided for sensing engine temperature and for switching off supply of current to the electrical heating means when the engine temperature reaches a predetermined temperature sufficient to heat the end region of the conductor to the required temperature to cause the fuel to vaporise substantially immediately upon ejection from the injector.

This aspect of the invention further provides a fuel injector for an internal combustion engine having a piston moveable in a cylinder, the injector including:

an end region;

a body;

electrical componentry in the body operable to enable fuel to be ejected from the end region of the injector; and

electrical heating means on the external surface of the end region for heating the end region of the injector, but not the body, so that when fuel is located in the injector and the electrical heating means operated, the fuel is ejected from the end region of the injector and substantially immediately converts to vapour because of the heating of the end region and therefore the fuel in the end region, and the change in pressure experienced by the fuel as the fuel leaves the end region of the injector.

In one embodiment the electrical heating means comprises an electrical heating pad in electrical contact with the end region, an insulating member between the pad and the engine, and an insulated electrical conductor in electrical communication with the pad so that current is supplied to the pad and then flows through the end region to heat the end region.

In another embodiment the electrical heating means comprises an insulated heating coil wound around the end region, and electrical conductors for supplying current to the coil so that the passage of current through the coil generates heat to heat the end region.

Brief Description of the Drawings

A preferred embodiment of the invention will be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a view of a fuel delivery system according to one embodiment;

Figure 2 is a fuel injection system according to a second embodiment;

Figure 3 is a side view of a gasket used in the embodiments of Figures 1 and 2;

Figure 4 is an end view of the gasket of Figure 3;

Figure 5 is a plan view of the gasket of Figures 3 and 4;

Figure 6 is a cross-sectional view through part of a gasket showing in more detail the formation of sealing projections on the gasket;

Figure 7 is a view of a further embodiment of the invention;

Figure 8 is a view of a component used in the embodiment of Figure 7; and

Figure 9 is a view of a further embodiment of the invention;

Figure 10 is a side view of a component used in the embodiment of Figure 9;

Figure 11 is a plan view of the component of Figure 10;

Figure 12 is a side view of a further component used in the embodiment of Figure 9;

Figure 13 is a plan view of the component of Figure 12;

Figure 14 is a detailed cross-sectional view of an injector in the injector port of an engine according to the embodiment of Figure 9;

Figure 15 is a view of an injector according to a still further embodiment; and

Figure 16 is a view of the injector of Figure 15 installed in an engine.

Detailed Description of the Preferred Embodiments

With reference to Figure 1, a fuel delivery system is shown for an internal combustion engine generally designated 10. The internal combustion engine includes a head 12 which has an inlet port 14 and an exhaust port 16.

A cylinder 18 is provided (and only schematically illustrated by the reference numeral 18) in which a piston (not shown) is located for reciprocating movement in the cylinder.

An inlet manifold 20 is connected to the head 12 by bolts (not shown) in the conventional manner. Located between the inlet manifold 20 and the head 12 is a gasket 22. The gasket is formed from heat conducting material such as aluminium or any other suitable metal or heat conducting material.

The gasket 22 is shown in more detail in Figures 3, 4 and 5. With reference to those figures, the gasket includes a plurality of openings 24. In the embodiments shown, the gasket is intended for a six cylinder in-line engine and has openings 24 corresponding to the six inlet ports 14 of the engine. The gasket 24 has lugs 25 which include holes 27 for receiving bolts (not shown) which are used to secure the manifold 20 to the head 12 and sandwich the gasket between the head 12 and the manifold 20.

The gasket 22 has a first side 28 and a second side 29. Arranged on the sides 28 and 29 are projections 30 and 31 which surround the openings 24.

As is best shown in Figure 5, the projections 30 (and also the projections 31) are preferably circular in configuration, but the shape will depend on the shape of the opening 24 which may change depending on the configuration of the engine concerned.

The projections 30 and 31 are preferably V-shaped in transverse cross-section, as clearly shown in Figures 3 and 4, and when the gasket 22 is sandwiched between the head 12 and the inlet manifold 20, the projections 30 and 31 deform to form a seal around the opening 24 and between

the end 14′ of the inlet port 14 and the end 20′ of the inlet manifold 20 so that air passing through the manifold 20 into the inlet port 14 is not able to escape between the inlet manifold 20 and the head 12 of the engine 10.

The inlet manifold 20 is provided with an injection port 35. The injection port 35 shown in Figure 1 is of standard size, and would normally fit a fuel injector which is provided with seals and an outer casing provided with the injector.

In the first embodiment of the present invention, the injector 50 has its seals and outer casing (neither of which is shown) removed, so as to expose end region 52. The end region 52 is formed from metal. In order to fill the space between the end region 52 and cylinder wall which defines the injector port 35, a collar of heat conducting metal is provided. The collar 40 has a bore 42 which receives the end region 52 in heat conducting contact, and the outer surface 43 of the collar 40 is in heat conducting contact with the wall 38 of the injector port 35.

The injector 50 has a body 54 which contains the electric operating components of the injector, such as the coil, armature, etc. for operating the injector 50 so that fuel can be ejected from the tip 56 of the end region 52.

Thus, according to this embodiment of the invention, heat which is transferred from the cylinder 18 to the head 12 is conducted through the heat conducting gasket 22 to the inlet manifold 20 and, in particular, the end region 23 of the manifold 20 in which the port 35 is formed. Heat is therefore able to conduct through the collar 40 to the end region 52 to heat the end region 52. Thus, the fuel in the end region 52 is elevated in temperature so that, as soon as the fuel leaves the tip 56, the fuel converts to

vapour immediately because of the elevated temperature of the fuel and the change in pressure the fuel experiences as soon as the fuel is ejected. Thus, the vapour is then conveyed along the inlet port 14 to the cylinder 18 for combustion in the cylinder 18.

This embodiment of the invention requires no alteration to the usual engine componentry, except for the conducting gasket 22 issues instead of a heat insulating gasket.

In the embodiment of Figure 2, the only modification is that the injector port 35 is changed from its standard size shown in Figure 1 to a much smaller size which matches the size of the end region 52 of the injector 50 after the seal and outer casing of the injector 50 have been removed. Thus, in this embodiment, the collar 40 is not needed and heat is conducted direct from the wall 38 of the injector port 35 to the end region 52.

In both embodiments of the invention, the body 54 is not in heat conducting contact with the engine, and therefore is maintained relatively cool compared to the end region 52 which is in heat conducting contact with the engine via the manifold 20 and the gasket 22. Thus, the body 54 is not heated and therefore, the electronic componentry within the body 54 is not damaged.

Figure 6 shows a section of the gasket 22 in more detail and describes how the projections 30 and 31 can be formed. In this embodiment, the gasket 22 is formed by a stamping or pressing operation, and a pressing or stamping tool (not shown) is provided with a zigzagged configuration which presses a V-shaped circular valley 60 around the opening 24, extending from side 29 of the gasket 22 and an upstanding peak 70 also of V-shaped configuration and also surrounding the opening 24. Thus, in this embodiment the projections 30 and 31 are formed by an appropriately

bending or deformation of the metal from which the gasket 22 is formed and are offset from one another.

In other embodiments the projections 30 and 31 could be formed in other fashions, including in a moulding operation or otherwise, although such techniques are likely to be more expensive than stamping or pressing the gasket 22.

Figures 7 and 8 show a further embodiment of the invention. This embodiment is the same as that of Figures 1 and 2, except that a housing 80 of insulating material is arranged over the end of the manifold 20 to surround the end of the manifold 20 which is in contact with the end region 52 of the injector 50. This will facilitate retention of heat in that part of the manifold 20, and therefore good heat conduction to the end region 52 of the injector 50. The body 54 is free of the housing 80 and therefore is maintained cool for the reasons specified previously. The housing 80 can be in the form of two halves which simply clip over the manifold 20 and which are supported on the engine head 12 by shelf section 81 locating on shoulder 83 (see Figure 1) of the head 12.

Figure 9 shows a further embodiment of the invention which is a modification to the embodiment of Figure 1. In this embodiment like reference numerals indicate like parts to those previously described. For ease of illustration, the gasket 22 and the engine 10 are omitted from Figure 9.

In this embodiment of the invention, the injector 52 is provided with an electrical heater which comprises a contact pad 90 formed from electrically conductive material, and an insulator 92 which is provided over the pad 90 and insulates the pad 90 from the collar 40 (or if the collar 40 is not used, as in the embodiment of Figure 2, from the inlet manifold 20). The ring 92 has a step

92a and an internal conical wall 92b. The pad 90 is connected to a battery 93 of the vehicle via a switch 94. A heat sensor 95 for measuring the temperature of the engine in the vicinity of the injector 50 (and in particular, the head of the engine or end region 23 of the manifold 20) is provided for operating the switch 94 to selectively allow current to flow to the pad 90 or to disconnect the flow of current from the pad 90.

As previously mentioned, the pad 90 is in electrical contact with the end region 52, but insulated from the collar 40 and an electric circuit is completed from the pad to earth via the end region 50 to the collar 40 and the manifold 20. Thus, when the switch 94 is switched on, current can flow from the battery 93 to the pad 90 and then through the end region 52 to the collar 40 and manifold 20 (and hence to earth). The insulator 92 prevents current from flowing directly from the pad 90 to the collar 40 without passing through the end region 52. The passage of the current through the end region 52 heats the end region so as to elevate the temperature of the end region during initial engine start-up, so that the end region 52 is heated to the required temperature to cause conversion of the fuel to vapour immediately upon ejection from the injector quicker than the time taken for the engine to heat to the required temperature after initial start-up to conduct sufficient heat to the end region 52 to cause the immediate conversion of fuel to vapour.

Tests have shown that the time taken for the engine to heat to a sufficient temperature to cause the end region to heat to the required temperature can be in the order of 200 seconds. The electrical heating pad increases the heat to the end region by about 1°C per second, and therefore as soon as the engine is switched on, the switch 94 can be activated so that current is supplied to the end region 52 and the end region will therefore heat to the

required temperature much quicker than waiting for sufficient engine temperature to develop for conduction of the required heat to the end region 52. Thus, the vehicle commences to operate with more fuel efficiency more quickly after engine start-up.

The temperature sensor 95 monitors the temperature of the engine, and as soon as the engine reaches the required operating temperature, the temperature sensor 95 can output a signal to cause the switch 94 to switch off so that heat is disconnected from the pad 92. At this time, sufficient heat has been developed for the conduction of heat from the manifold 23 to the end region 52 in the manner previously described to elevate the temperature of the end region 52 to that required to cause the vaporisation of the fuel as soon as the fuel leaves the injector 50.

This embodiment therefore provides the further advantage of providing fuel efficiency more quickly after initial engine start-up.

Figures 10 to 14 show the structure of this embodiment in more detail.

As is shown in Figures 10 and 11, the pad 90 comprises a ring 90a of heat conducting metal to which is connected a terminal 90b by a conductor 90c. The ring has an inclined or conical side wall 90d. The conductor 90c is insulated and the terminal 90b connects to a lead (not shown) from the switch 94 so that electric power can be supplied to the terminal 90b, the lead 90c and then to the ring 90a.

Figures 12 and 13 show the insulator 92 which is also in the form of a ring formed from any suitable insulating material such as rubber or the like. The ring 92 is a tight fit over the pad 90a to securely hold the pad 90a

against the end region 52 of the injector 50, and to insulate the tab 52 from the adjacent part of the collar 40. As shown in Figure 12, the ring 92 has a step section 92a and an internal conical wall 92b.

Figure 14 shows more detail of the actual structure of Figure 9 and the pad shown in Figures 10 and 11 and the insulating ring shown in Figures 12 and 13 in an assembled condition. In this embodiment the collar 40 is provided with an internal wall 38 which has an inclined shoulder 38a and a short stem section 39b which defines the opening of the collar 40 which faces the inlet port of the engine.

The end region 52 of the injector 50 is provided with a conical end surface section 50a and the conical wall 90d sits on the conical wall 50a of the injector end region 52. The lead 90c extends between the end region 52 and the wall 38 of the collar 40 and underneath O-ring 99 which can be provided to seal the injector 50 in the collar 40 if desired.

The insulating ring 92 sits over the pad 90 with the internal conical wall 92b rested on the pad 90 and sandwiching the pad 90 between the conical wall 92b and the conical wall 50a of the end region 52. Thus, the pad 90 is pushed into electrically conducting contact with the end region 52.

The inclined wall 38a and the stem 39b register in step 92a to facilitate location of the injector 50 and also holding of the injector 50 in the collar 40. The external wall 52c of the end region 50 is therefore in contact with the internal wall 38 of the collar 40, although, for illustrative reasons in Figure 14, a slight space can be seen. Thus, heat is still able to conduct from the collar 40 to the end region 52 in the manner described in the earlier embodiment.

Thus, as is previously described, heat can initially be applied by the pad 90 to the end region 52 to heat the end region, and when the engine warms to the required temperature, heat is conducted via the collar 40 to the end region 52 in the manner described in the previous embodiment.

Figure 15 shows a second embodiment of the invention. In this embodiment the injector 50 is provided with an electrically insulated heating coil 100 which is wound all the way along the end region 52. The coil 100 has ends which are connected to conductors 101 and 102 which are connected to the positive terminal of the vehicle battery and to earth respectively. Electric current is supplied to the coil 100 which heats up due to the flow of current through the coil 100, and in turn heats the end region 52. Thus, the end region 52 is elevated to the required temperature to cause the fuel to immediately convert to vapour upon ejection from the injector 50.

In this embodiment, a seal 103 may be provided so as to slightly space the coil 100 from the collar 40 or the internal wall 38 of the injector port 35 (as the case may be). In this embodiment all of the heat for supply to the end region 52 is provided by the heating coil 100 rather than heat conduction from the engine. Thus, in this embodiment the gasket between the manifold 20 and the engine 10 can be the conventional insulating gasket.

Figure 16 shows the injector of Figure 15 located in the engine in the arrangement in which a collar 40 is used. This embodiment is also applicable to the situation of Figure 2 in which the injector port 35 is drilled to match the size of the end region 52 having the coil 100. Thus, in this alternative arrangement, injector port 35 can be drilled to a smaller size to match the diameter of the end

region 52 with the coil 100, and again, if desired, the coil can be slightly spaced from the wall of the port 35 by a seal similar to the seal 103 shown in Figure 15.

As in the previous embodiments, the electrical heating element provided by the pad 90 or the coil 100, heats only the end region 52 of the injector 50 and not the body 54. Thus, the body 54 is not elevated in temperature and remains in the free air where it is cool, and therefore the heat supplied by the electrical heating system of Figures 9 to 14 or Figures and 16 does not detrimentally effect operation of electronic components within the body 54.

Embodiments of the invention which use the electrical heating system of Figures 9 to 16 are most suitable for vehicles which have relatively high voltage electrical supply, such as 24 volt operation so that the current drawn does not create too great a load on the engine, and therefore defeat the purpose of heating the end region. If the current drawn increases the load on the engine to too great an extent, the engine will require a greater amount of fuel to operate at the same level as without the electrical system.

The present invention enables fuel savings and therefore greater economy because the amount of fuel which is required can be decreased. This is performed by ensuring that the injector injects a smaller quantity of fuel each time the injector is opened. However, if it is desired to provide greater performance, such as in the case in a racing car or the like, then the present invention, because of the complete vaporisation of all the fuel ejected by the injector, can allow the injector to be operated such that a larger amount of fuel is provided each time the injector is opened. Because of the vaporisation of the fuel, the additional fuel imputed into

the engine will not adversely affect the spark from the spark plug of the engine, which is the case if an attempt is made to increase the delivery of liquid fuel to the engine, and which therefore may result in the greater volume of fuel putting out the spark and causing a misfire. Thus, greater performance can be achieved in racing environments or the like by the addition of more fuel so that greater power from each combustion in the combustion chamber is achieved.

Since modifications within the spirit and scope of the invention may readily be effected by persons skilled within the art, it is to be understood that this invention is not limited to the particular embodiment described by way of example hereinabove.

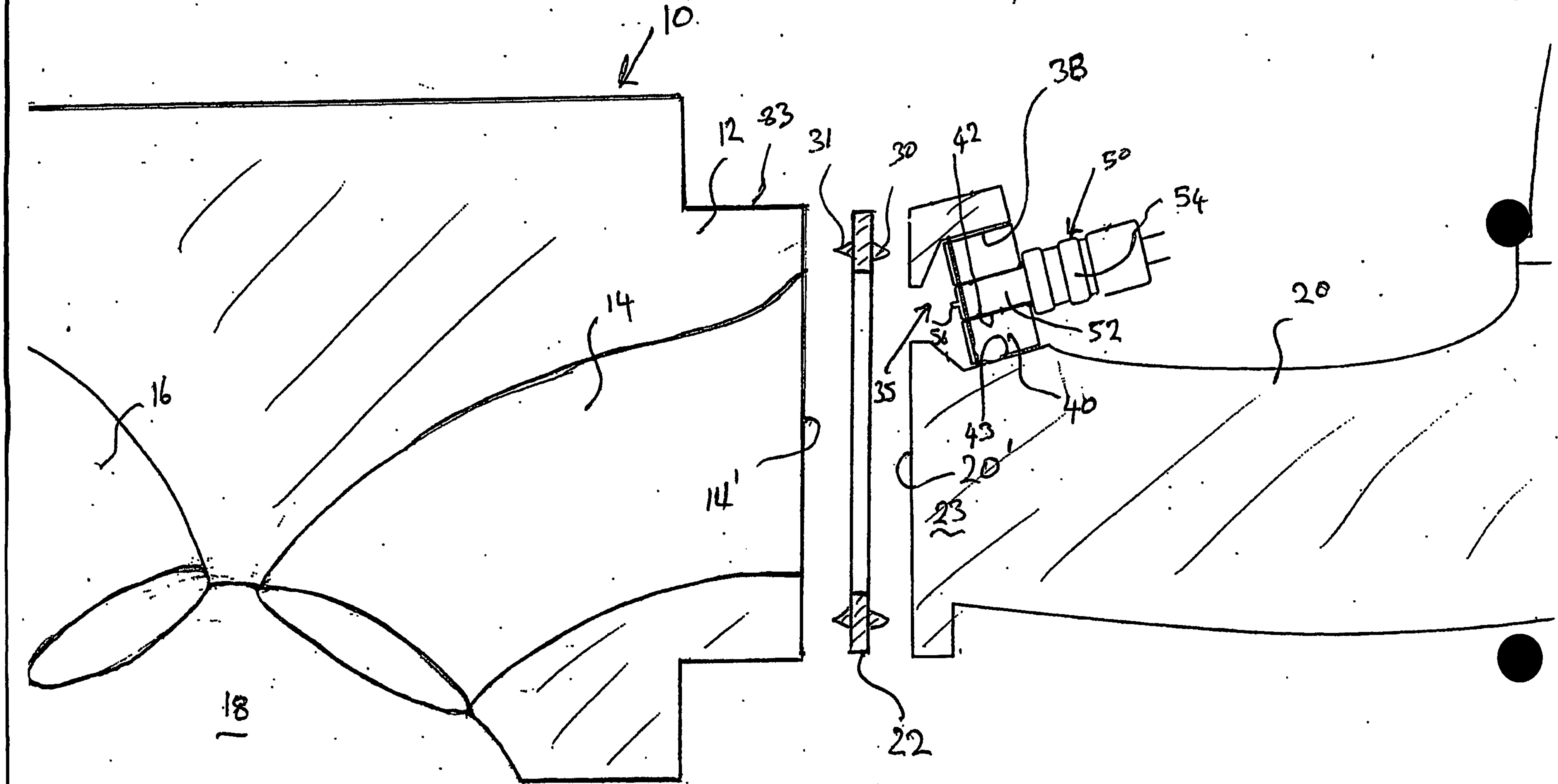


Fig 1

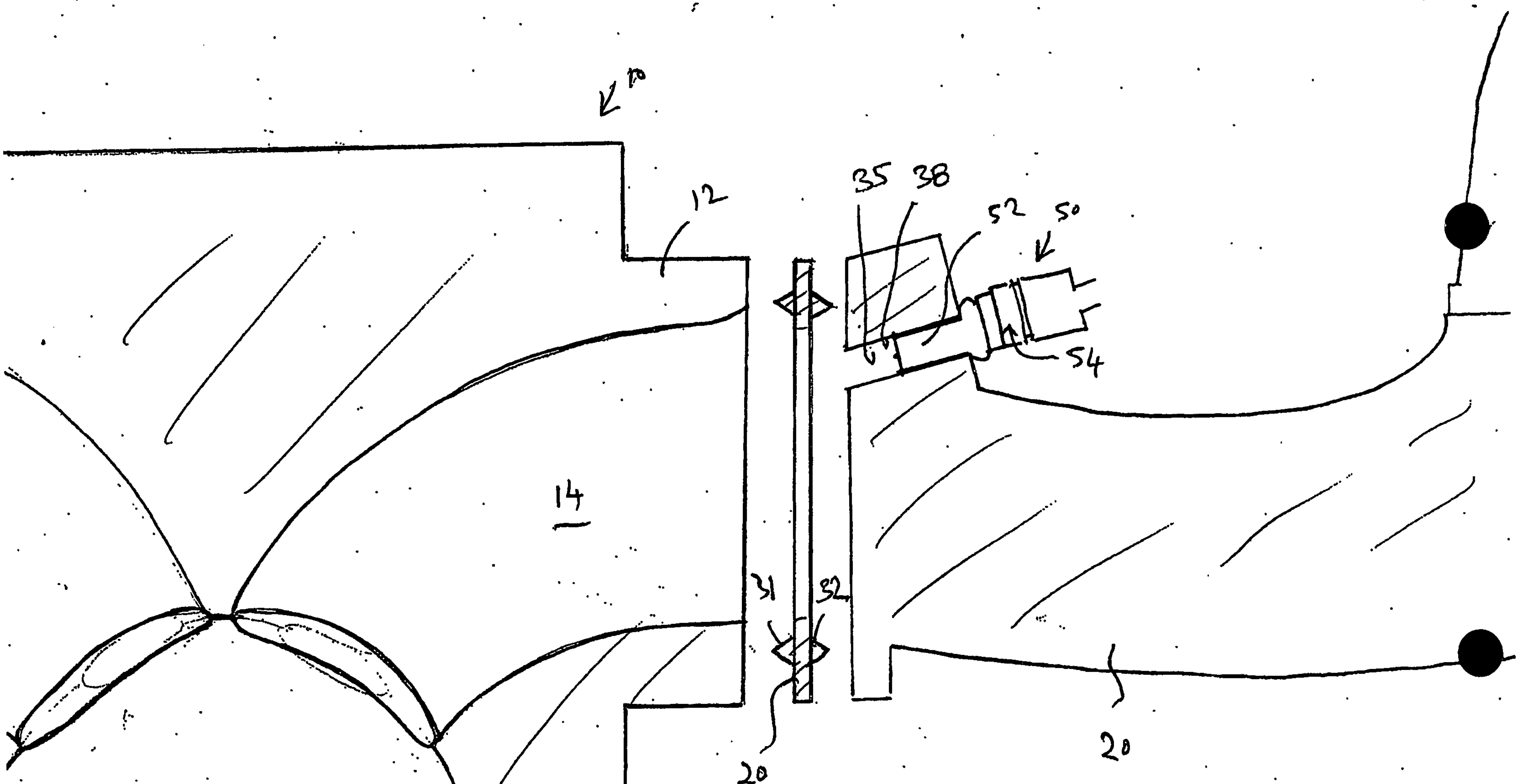


Fig 2

CROSS SECTIONAL VIEWS - ,
SHOWING RAISED CRUSH AREAS .
OLT HOLES.

Fig 4

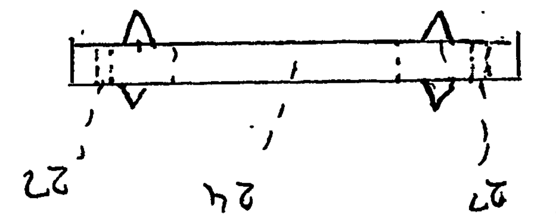
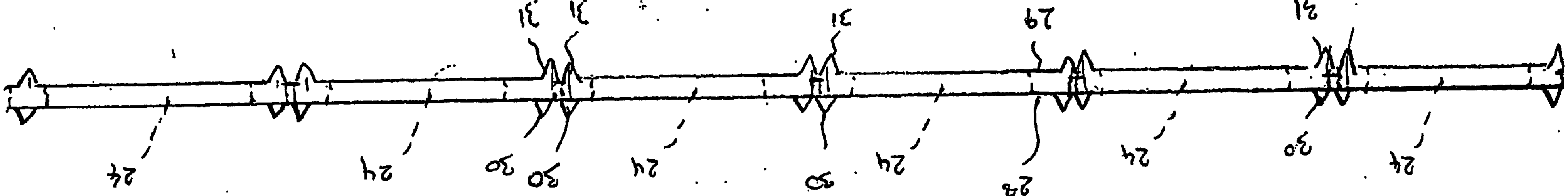


Fig 3



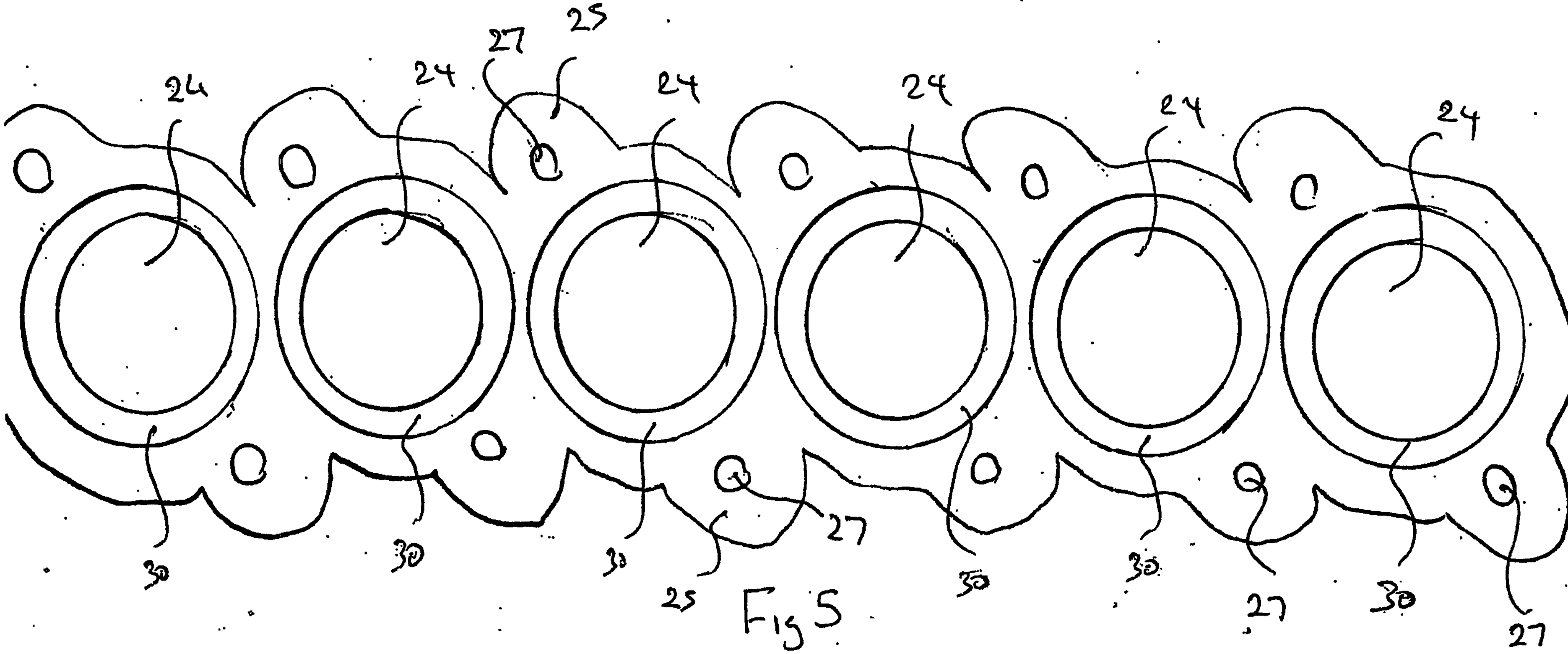


Fig 5

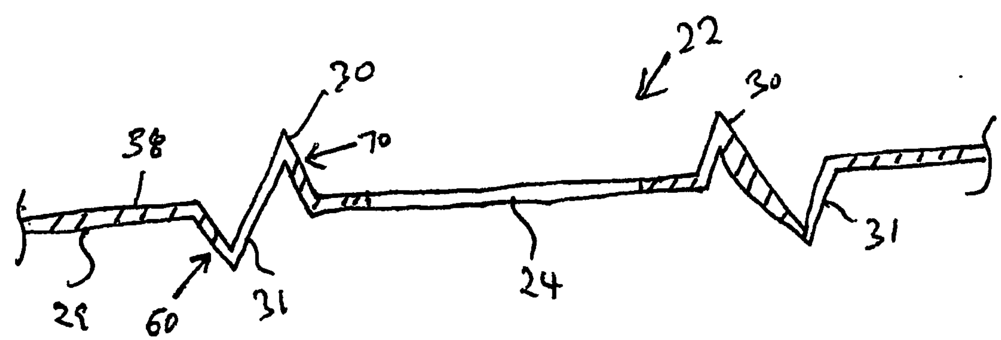


Fig 6

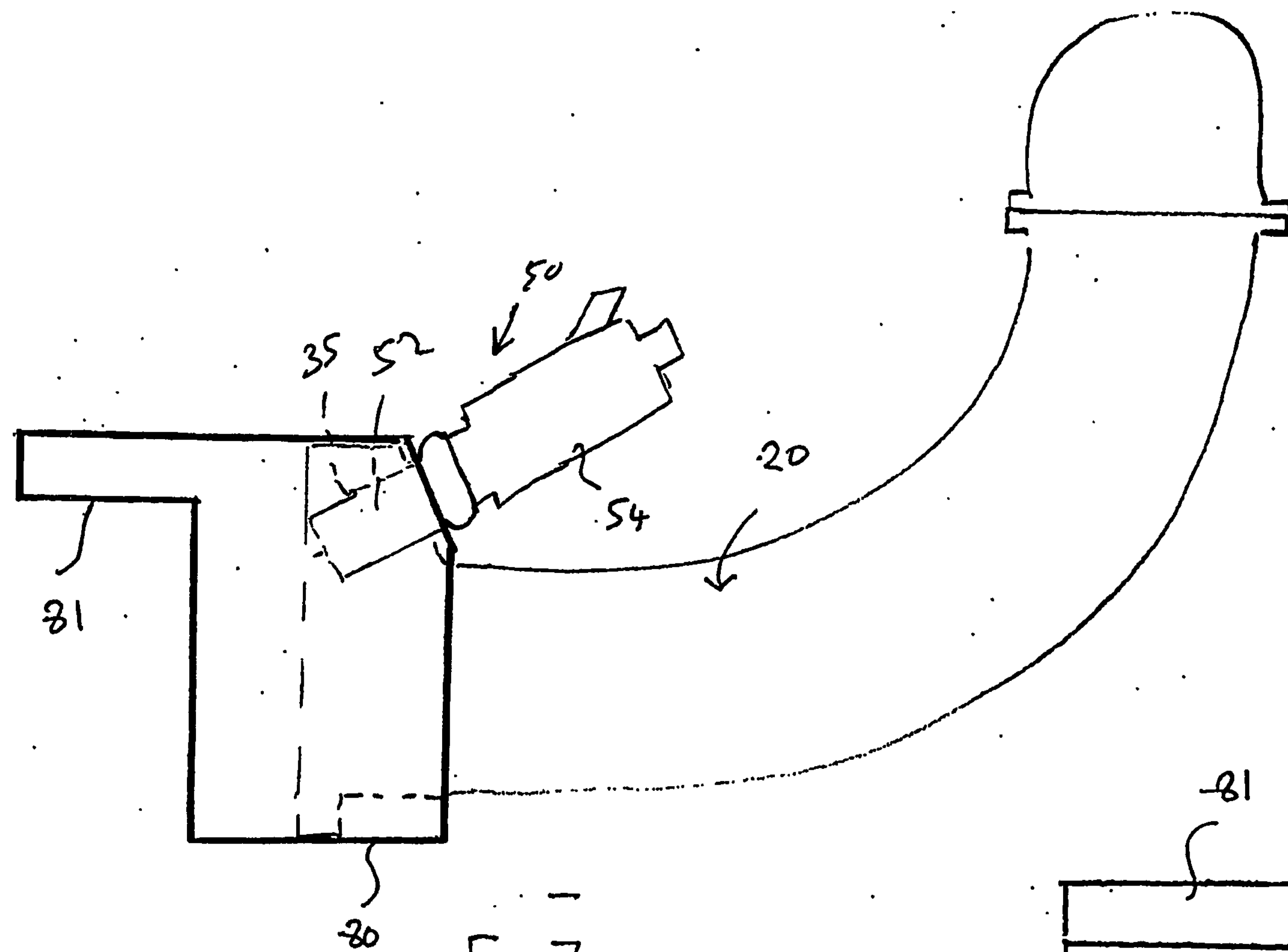


Fig 7

FRONT ELEVATION

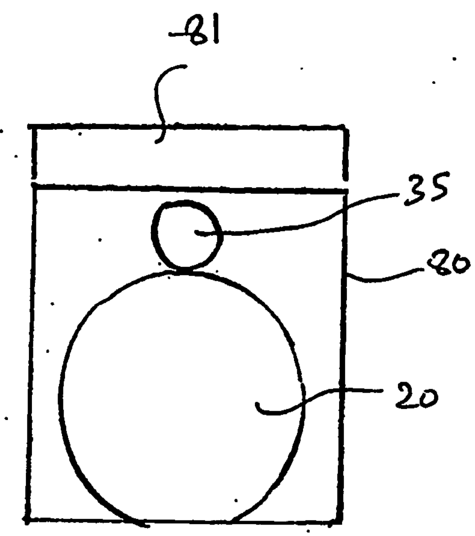


Fig 8

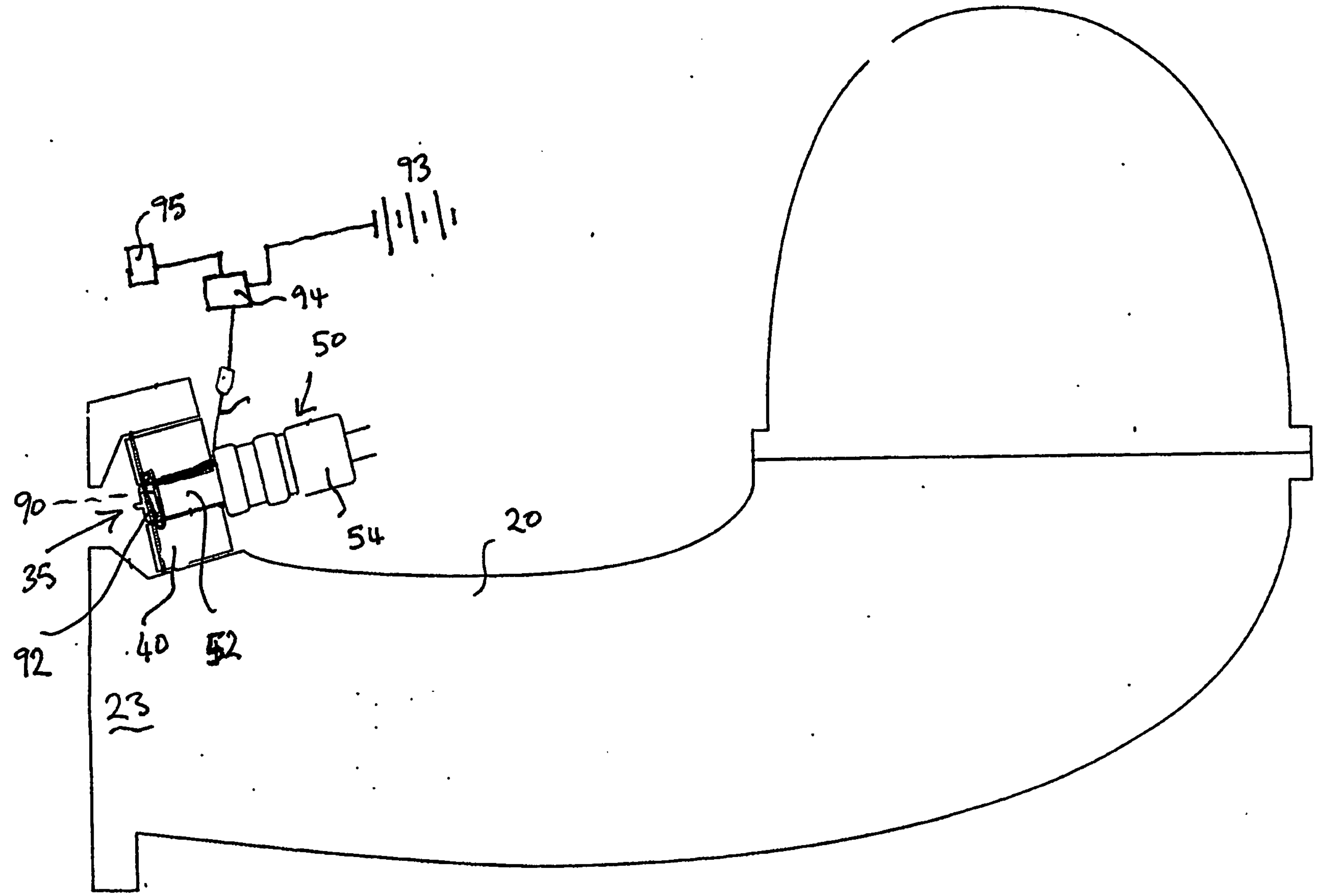


Fig 9

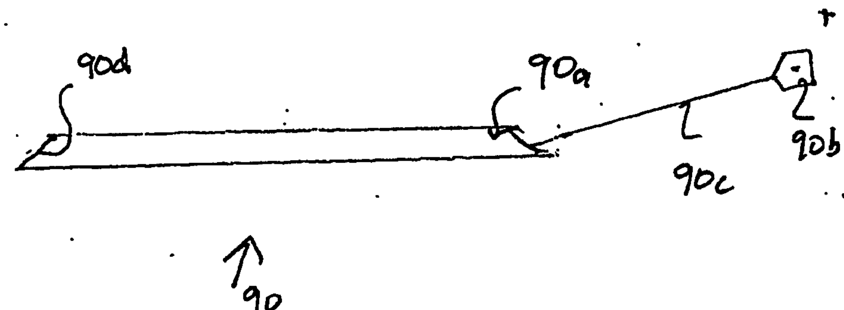


Fig 10

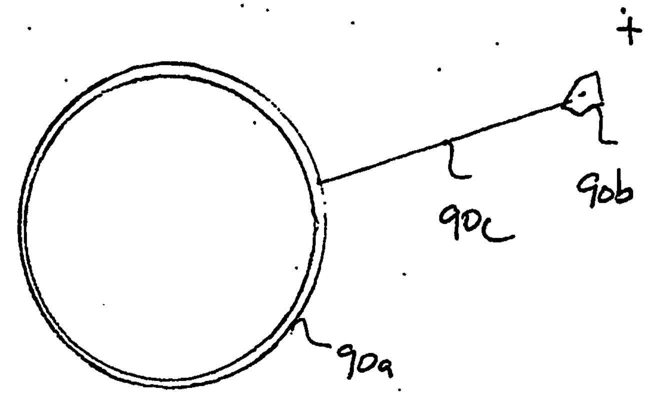


Fig 11

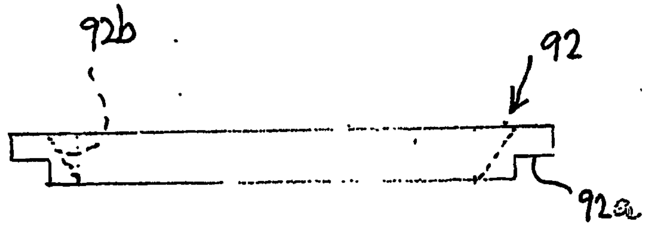


Fig 12

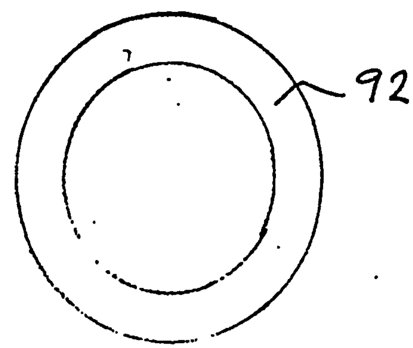


Fig 13

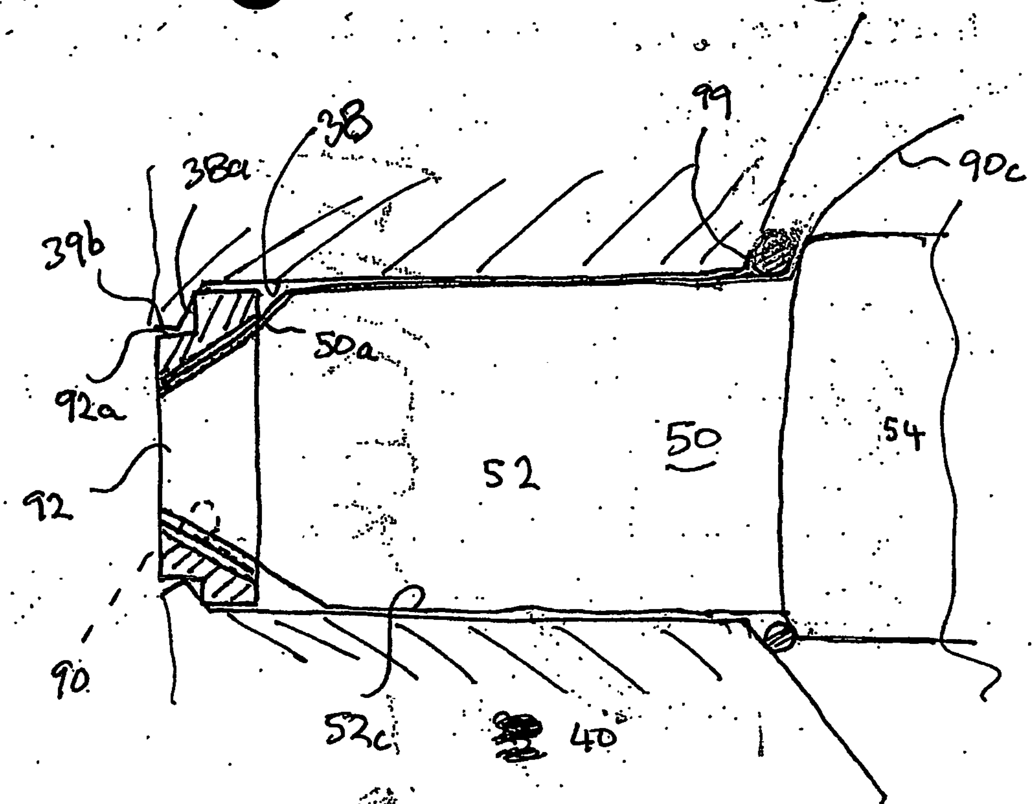

38
38a
39b
92a
50a
92
90
99
90c
52
50
54
52c
40

Fig 14

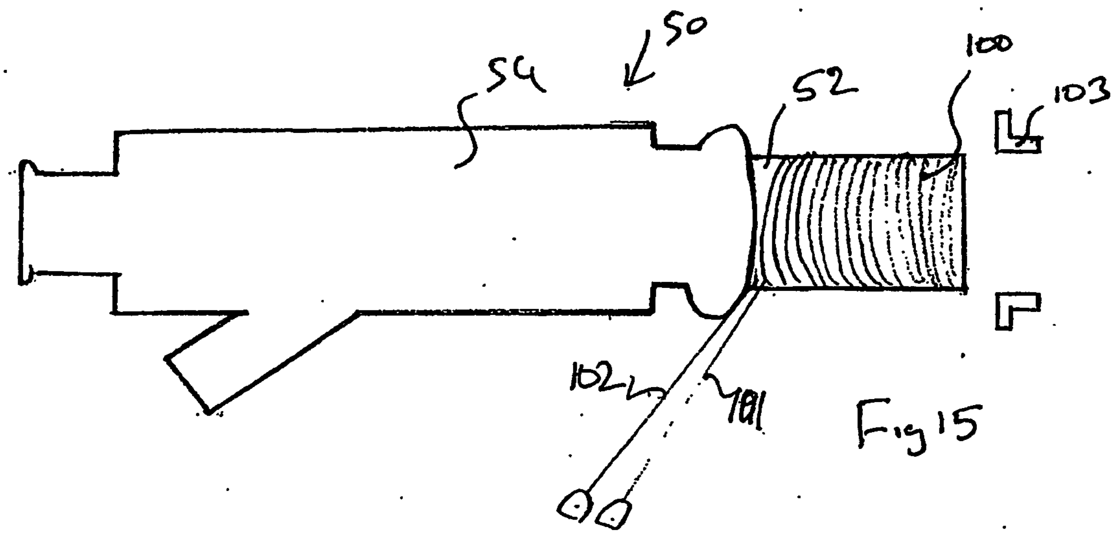

50
54
52
100
103
102
101

Fig 15

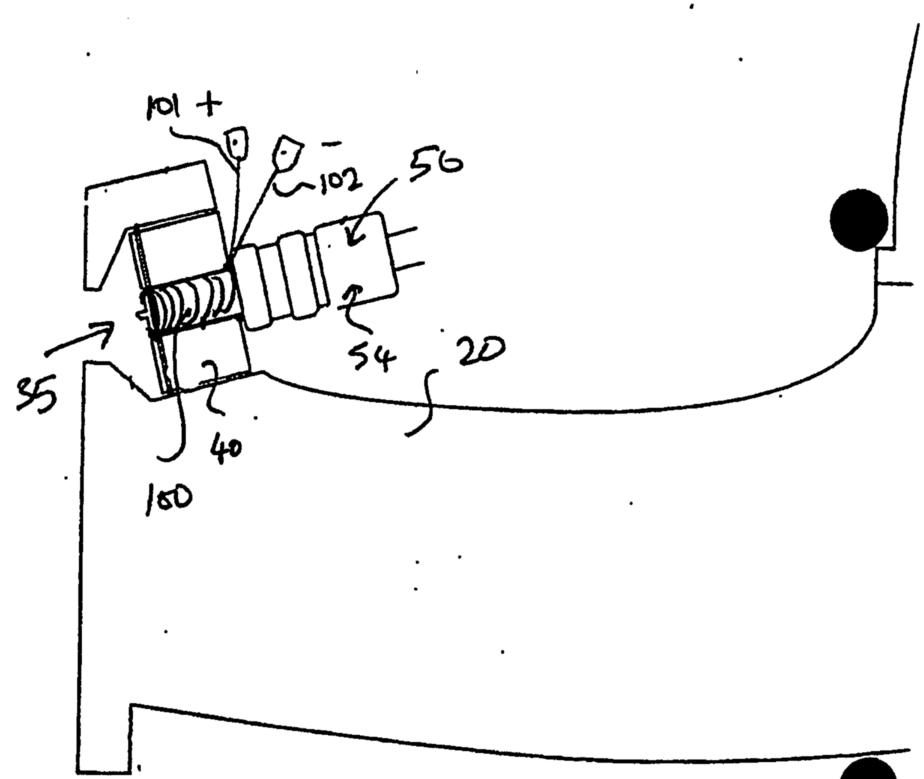


Fig 16